

Rollovers

Configuration, Kinematics, and Injury

San Diego CIREN



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Today's Presenters

A. Brent Eastman, MD, FACS

Carol Conroy, MPH, PhD, Epidemiologist

Steve Erwin, Crash Investigator

Contributors

Sharon Pacyna, RN, MPH

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Today's Presentation

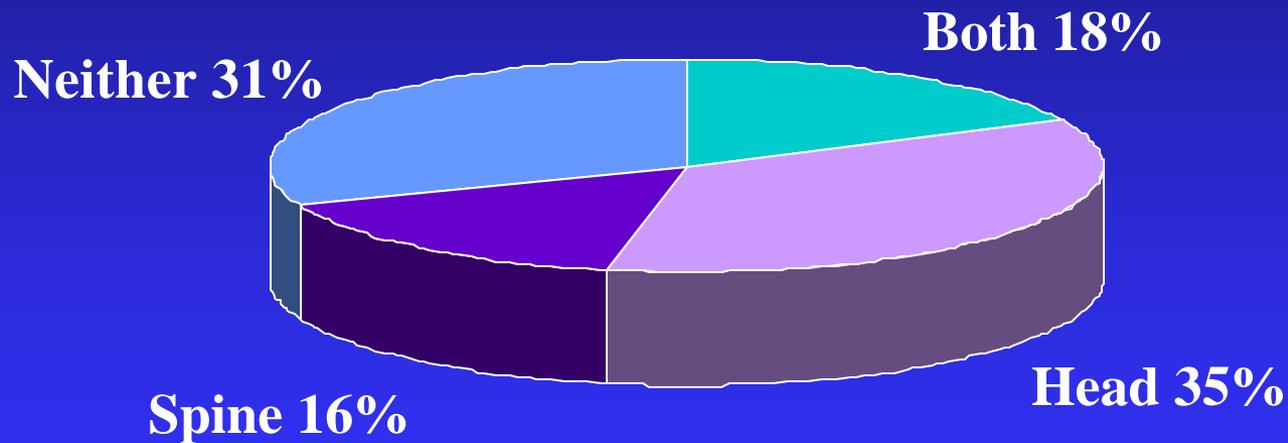
- The Rollover Problem
- CIREN Statistics
- Rollover Causation/Types
- Safety Standards
- Kinematics
- Case Studies

Magnitude of the Problem

- Almost 215,000 passenger vehicles are in tow-away rollovers every year
- Rate of serious injury is 36% higher than in collisions with no rollover
- 3-4% of all crashes are rollovers, but 20% of all fatal crashes involve rollovers
- About 2/3 of rollover deaths involve occupant ejection

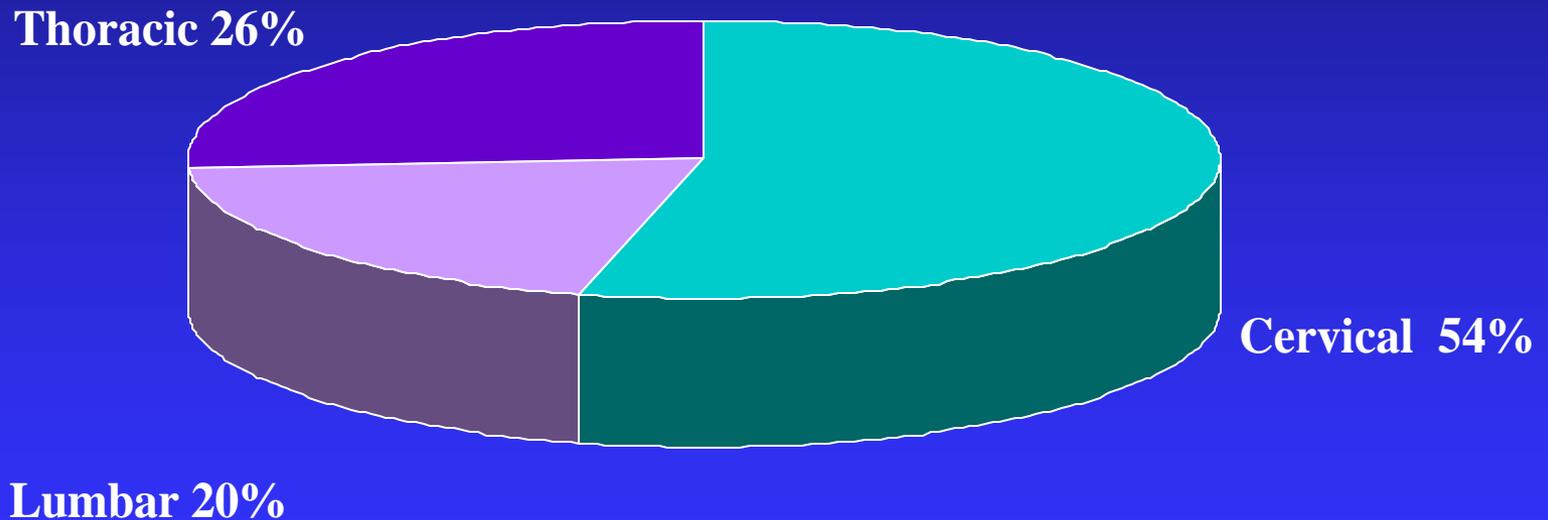
CIREN Statistics

Head and Spinal Injuries in Occupants in Rollover Crashes (CIREN 1995-2004)



Spinal Injuries in Occupants in Rollover Crashes

(CIREN 1995-2004)



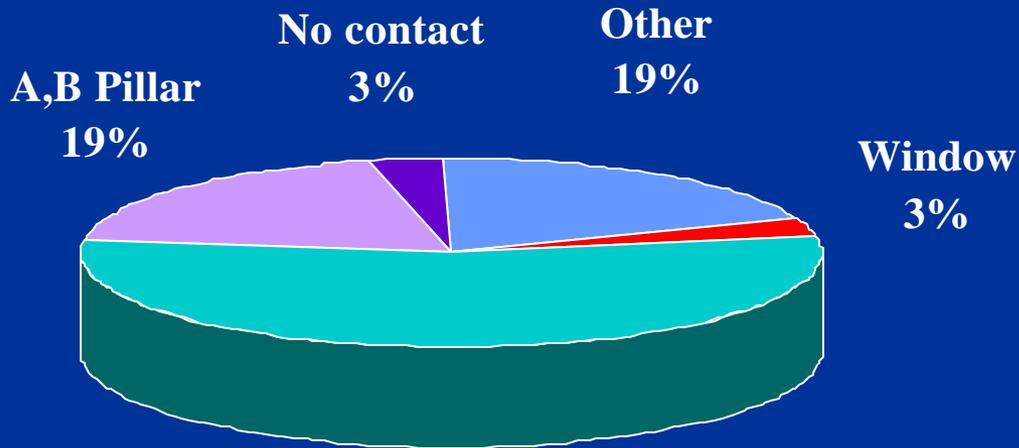
n=121

12%: Cervical and Thoracic, 7%: Lumbar and Thoracic, 5% Cervical and Lumbar

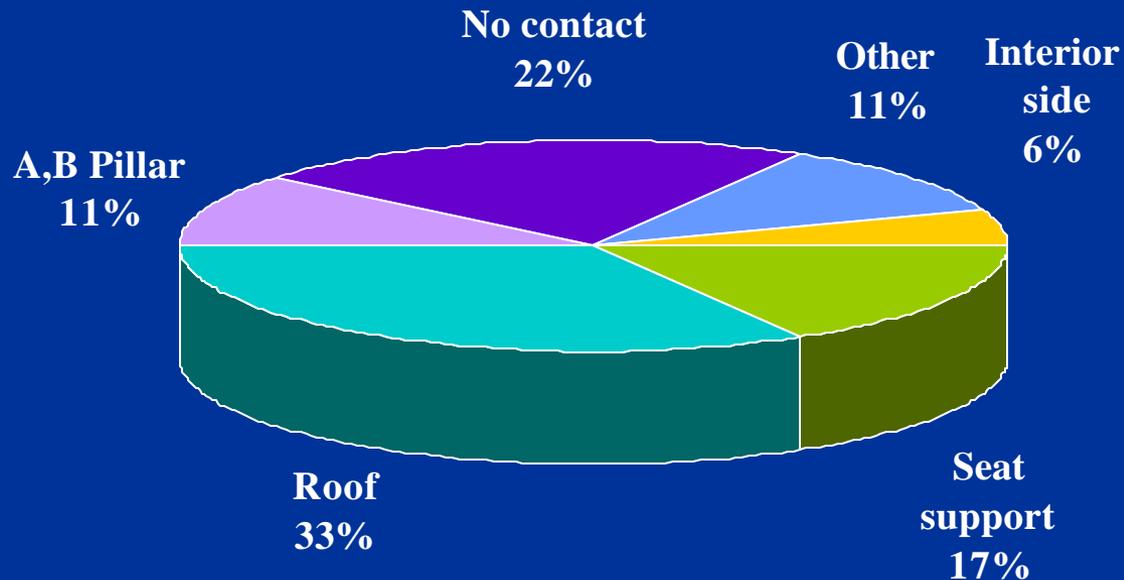
Sources of Injury for Occupants in Rollover Crashes

(CIREN, 1995-2004)

Head Injury



Spinal Injury



Role of safety belts in preventing head and spinal injuries to drivers in rollover crashes (CIREN, 1995-2004)

- Unbelted drivers were 2.6 times more likely to have head injury alone compared to belted drivers*
- Unbelted drivers were 1.8 times more likely to have spinal injury alone compared to belted drivers
- Unbelted drivers were 4.7 times more likely to have **both** head and spinal injuries compared to belted drivers*

* P < 0.05

Rollover Causation

- Driver Behavior
 - Steering inputs
 - Unsafe driving speeds
- Environmental Conditions
 - Terrain
 - Road Conditions
- Vehicle Design
 - Static Stability Factor (“top heaviness”)
 - one-half the track width divided by the height of the center of gravity

Rollover Types

TRIPPED EVENTS

- Trip-Over
- Flip-Over
- Climb-Over
- Fall-Over
- Bounce-Over

UN-TRIPPED EVENTS

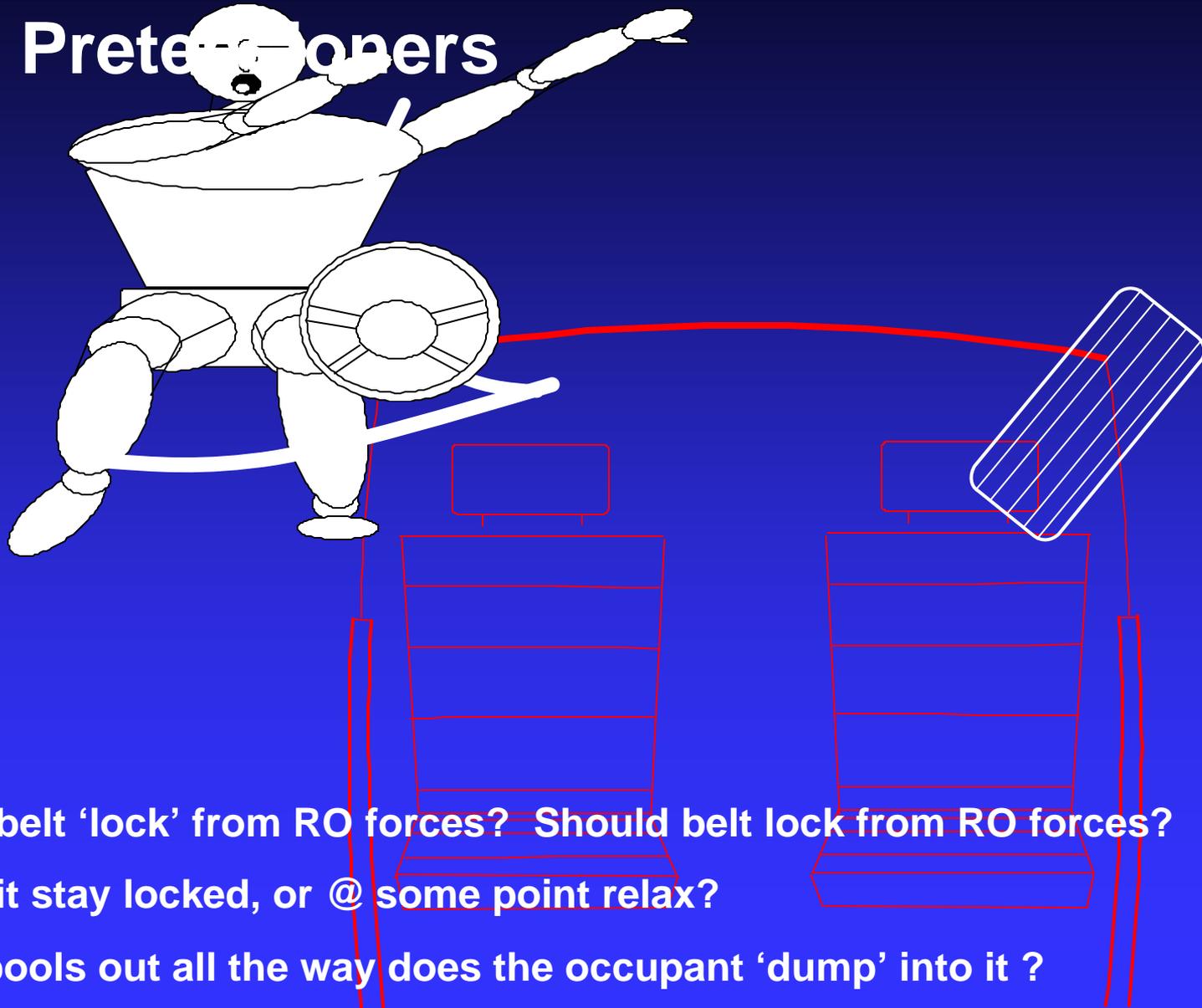
- Turn-Over

Safety Standards

- FMVSS 216 Roof Crush
- FMVSS 206 Door Locks & Door Retention
- FMVSS 201 Interior Padding
- FMVSS 205 Glazing Materials

- Curtain Airbags
- Seat Belts

Retractors - ELR/ALR and Pretensioners



Does belt 'lock' from RO forces? Should belt lock from RO forces?

Does it stay locked, or @ some point relax?

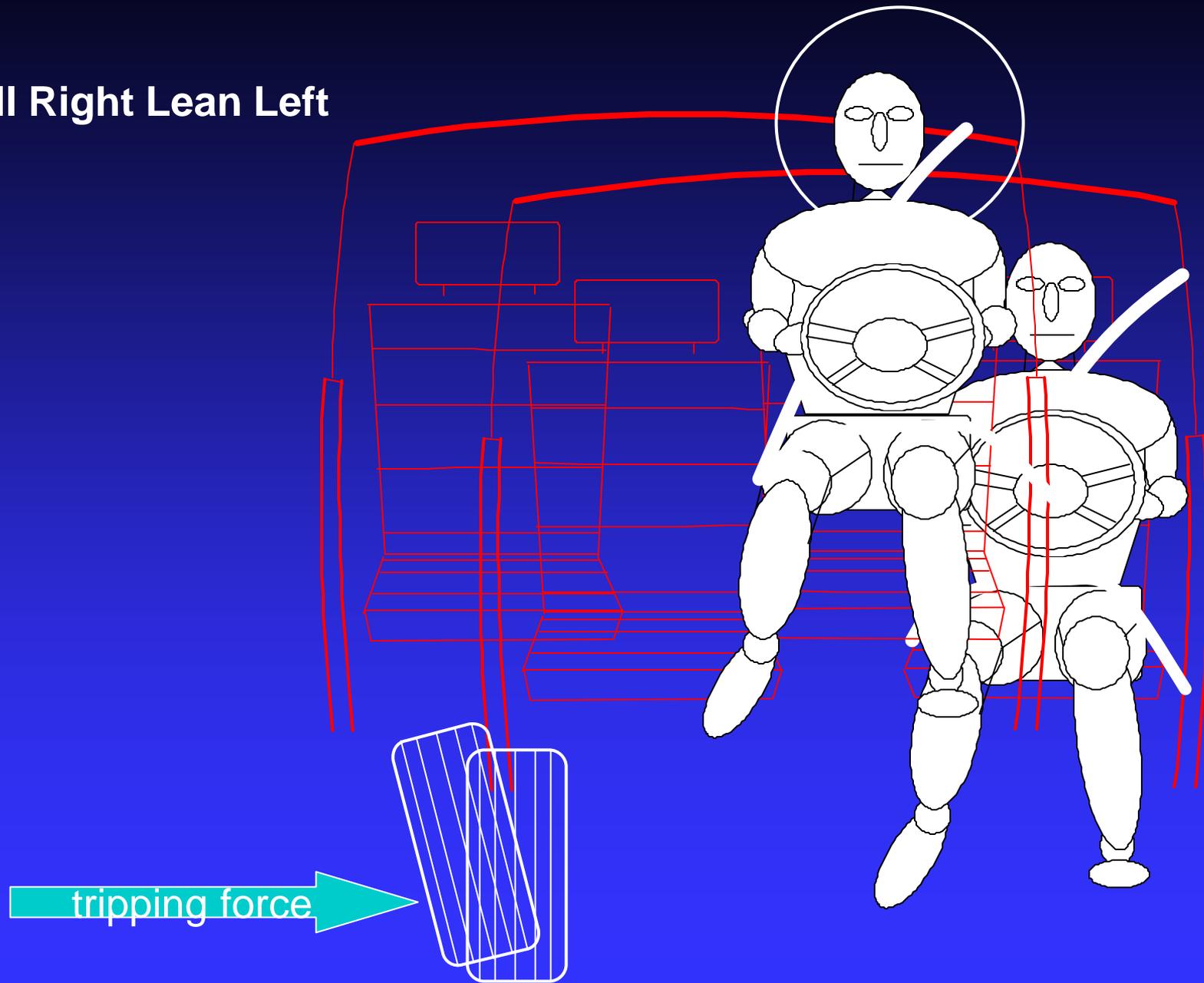
If it spools out all the way does the occupant 'dump' into it ?

Occupant Kinematics - Considerations

- Occupant position and roll direction
- Velocity changes during impact(s)
- Roof crush and restraint use
- Roll right, lean left

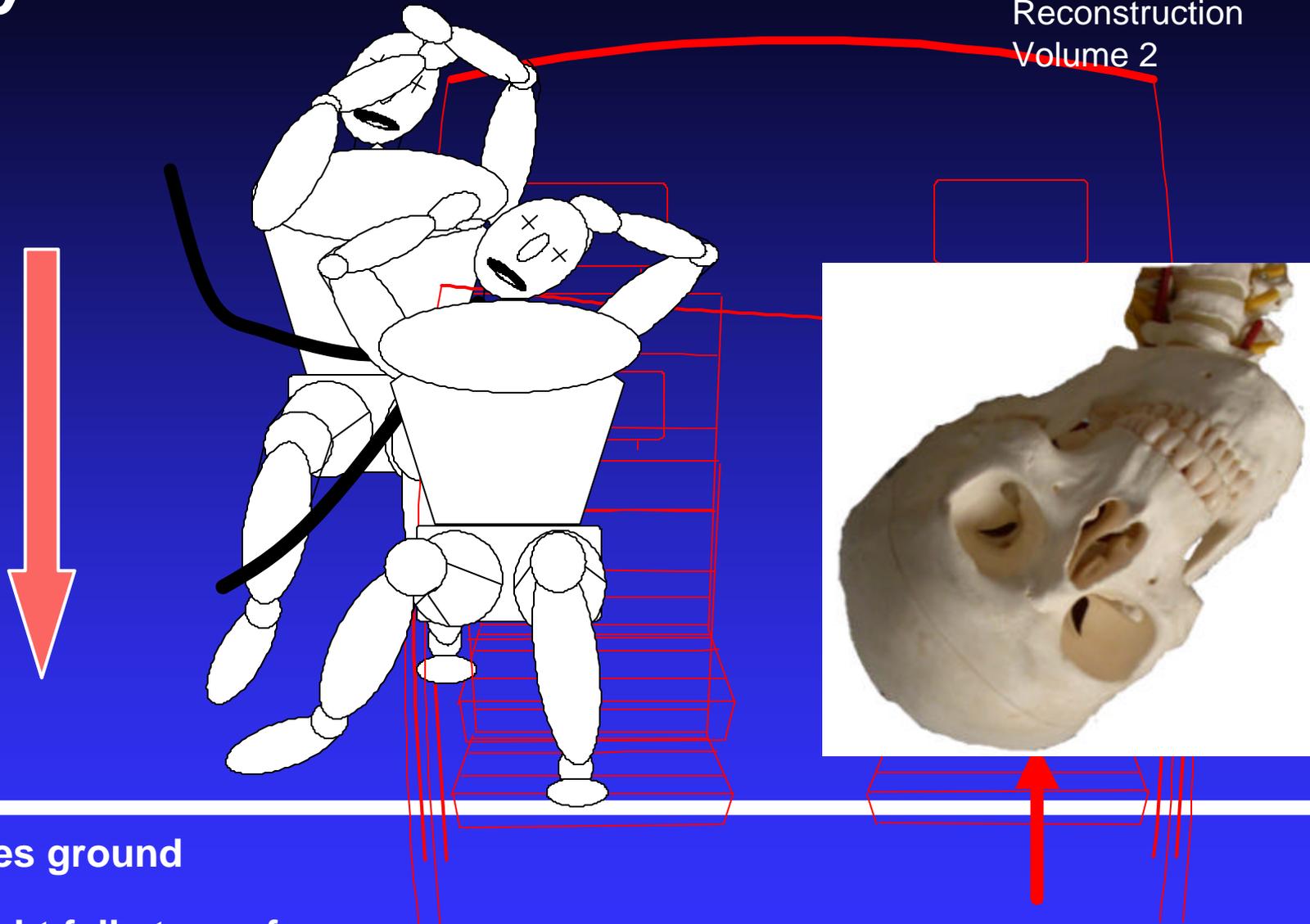
R/O Kinematics

Roll Right Lean Left



Gravity

* Fricke, Traffic Accident Reconstruction Volume 2



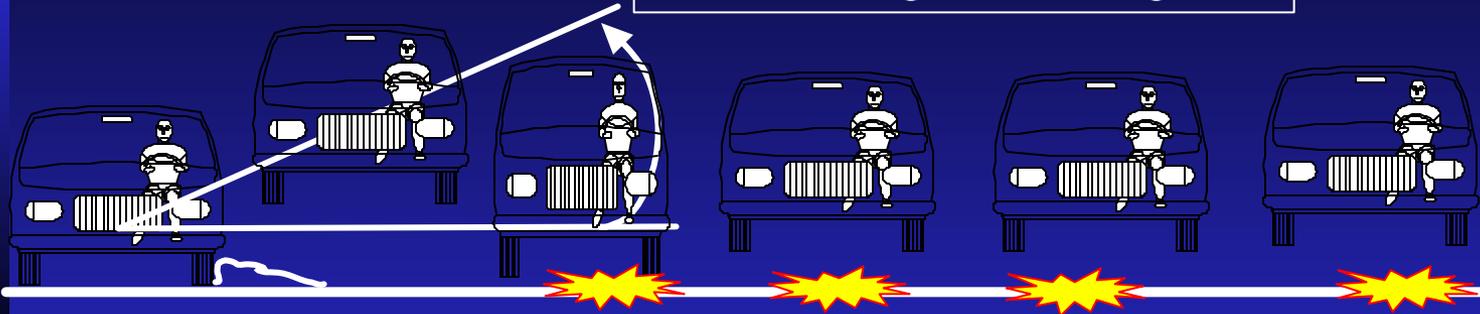
1) Roof strikes ground

2) Body weight falls to roof

3) Weight of vehicle continues down, crushes roof while occupant lays against it

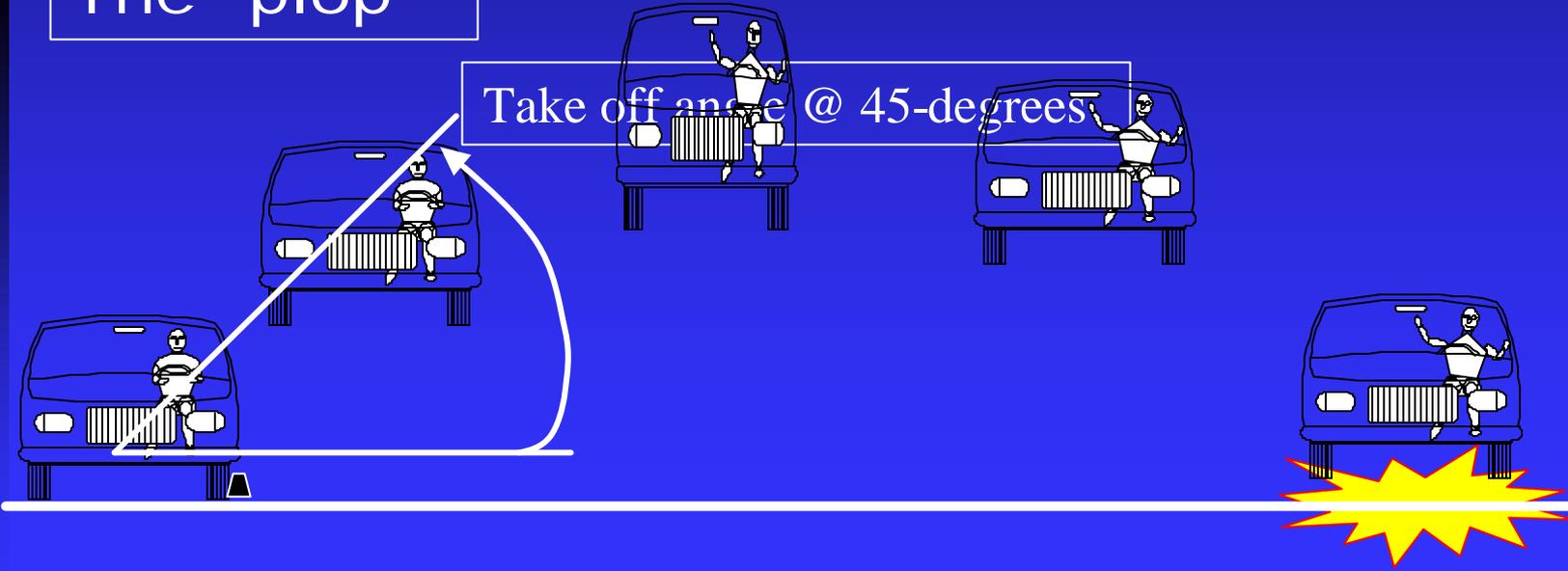
The "skipping stone"

Take off angle < 45-degrees



The "plop"

Take off angle @ 45-degrees



Additional Data Collection on Rollover Crashes

1. Location (on vehicle) of first 'touchdown'

2. Velocity @ trip



Velocity from "FLIP":

$$V = d \sqrt{\frac{g}{d-h}}$$

3. Distances:

* trip to 1st touchdown

* trip to FRP

4. Bending of roof structures

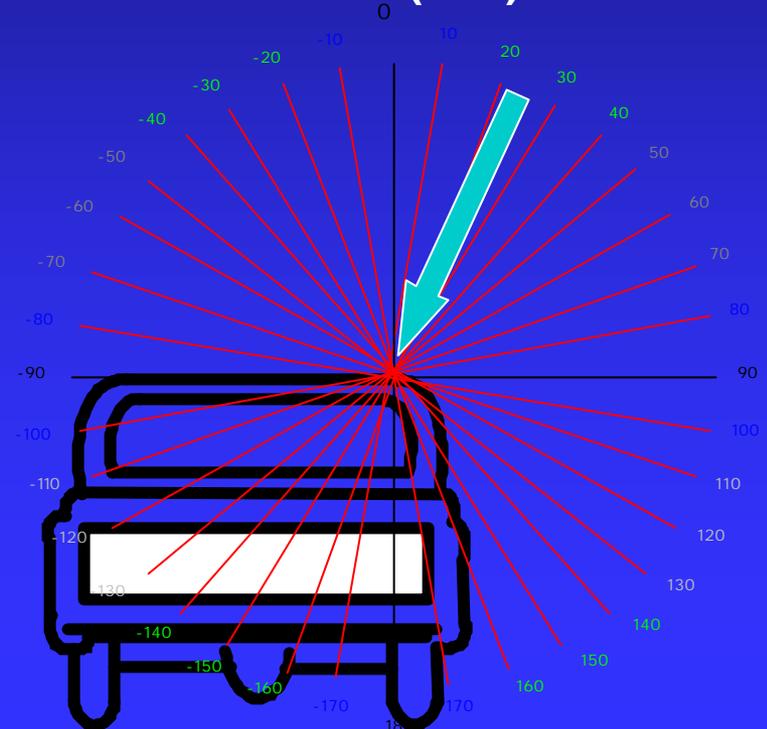
5. Number of impacts to the 'greenhouse'.

6. 'Sub CDC's' for non-horizontal impacts to the greenhouse within the sequence



7. Categorize them according to the DV dispersal: "Skipping stone & the plop"

Non-horizontal (N/H) PDOF ?



CIREN

Case Presentations

Subject – Driver
Right side leading-
tripover



Crash

Case Vehicle

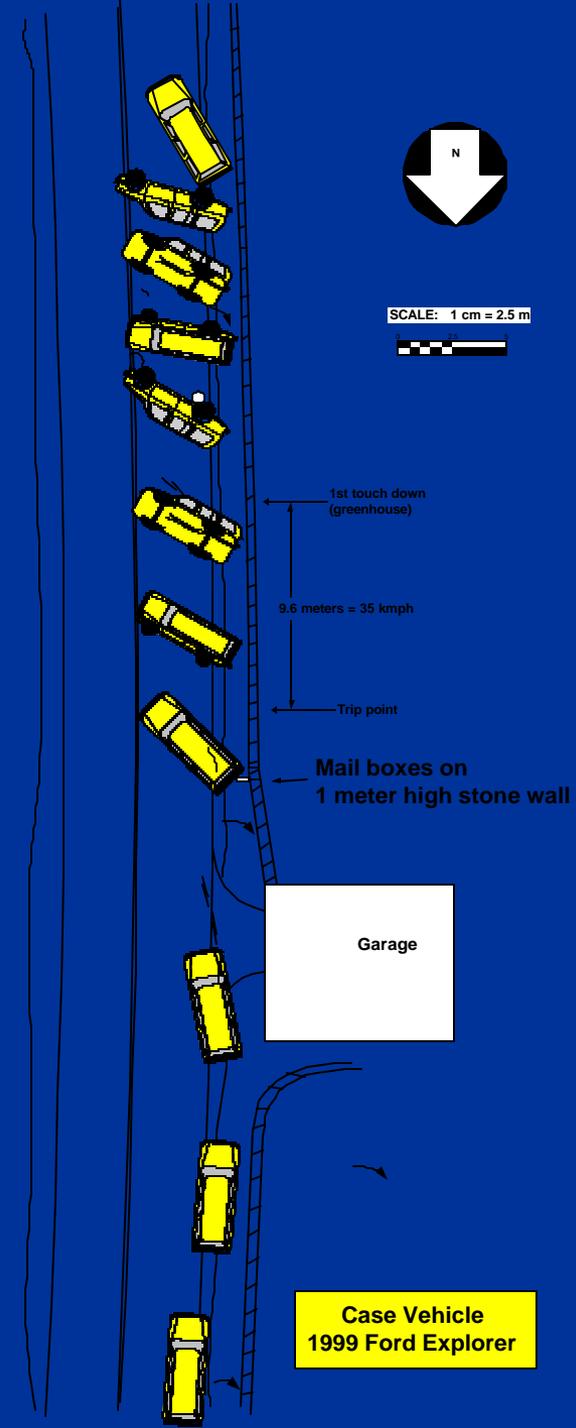
- * 1999 Ford Explorer
- * Max. Crush 43 cm @ driver roof/A pillar
- * 2 greenhouse impacts

Rollover -

- * right side leading
- * 8 quarter-turns (2 complete Overturns)
- * FRP on wheels
- * 35 kph (22 mph) velocity @ trip

Scene -

Clear, dry, daylight,
slight downgrade, bituminous



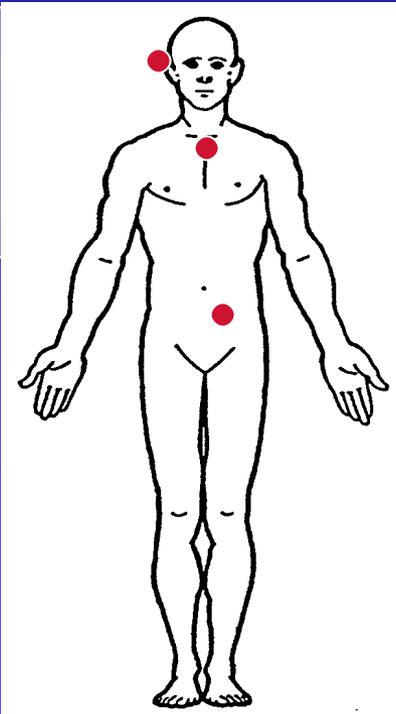
Subject:

Driver, sole occupant

- 53 y/o male, 6', 230 lbs.
- Lap & shoulder belt in use (not pre-10, not integrated)
- Front impact airbag not deployed (no side bags)

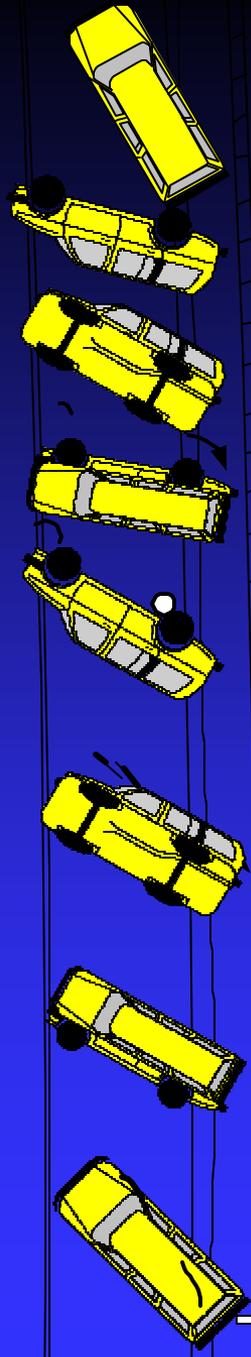
Posterior scalp avulsion

Right ear laceration and contusion



Left comminuted C4-5 facet fx. and C4 lamina fracture

Left abdominal contusion



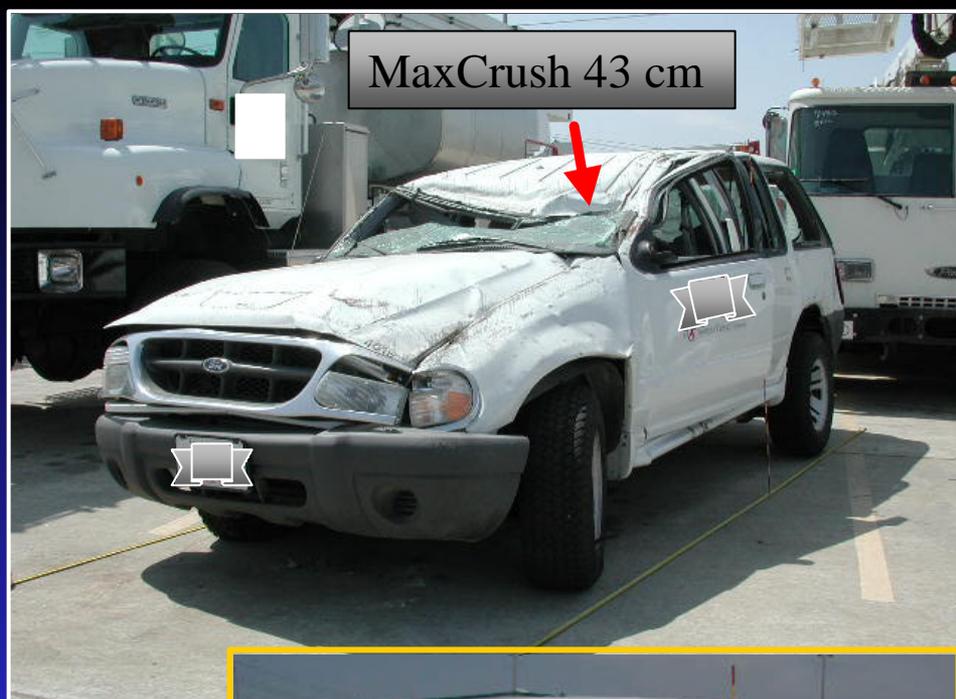
1st touch down (greenhouse)

9.6 meters = 35 kmph

Trip point

Mail boxes 1 meter high





Like Vehicle





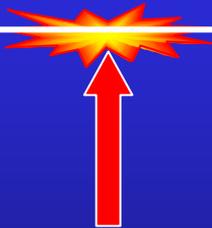
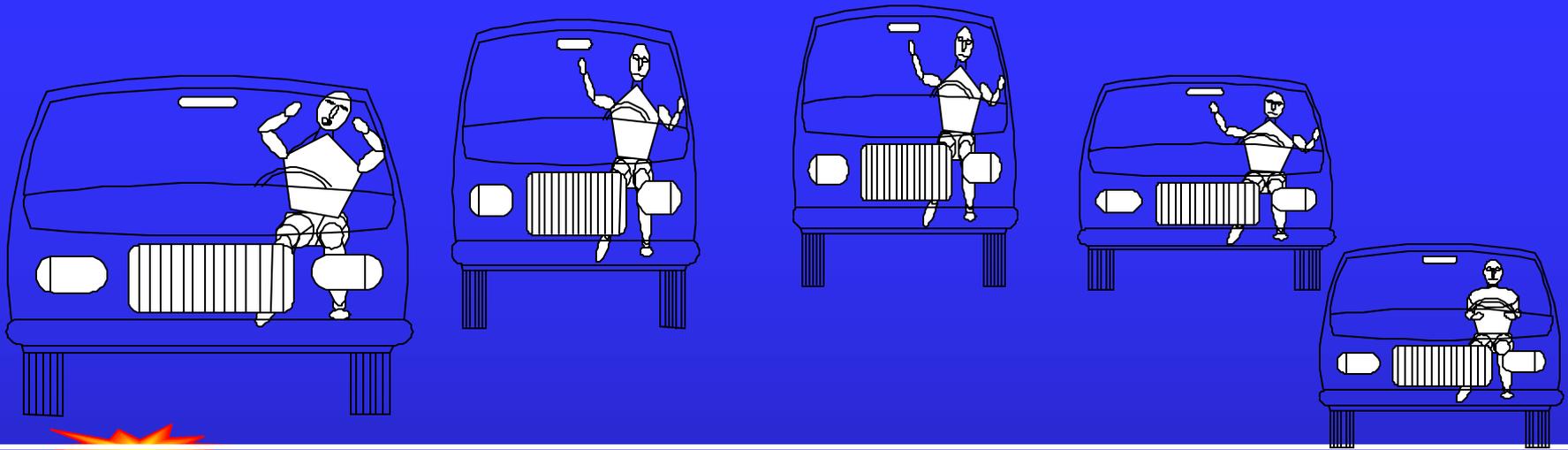
Like Vehicle



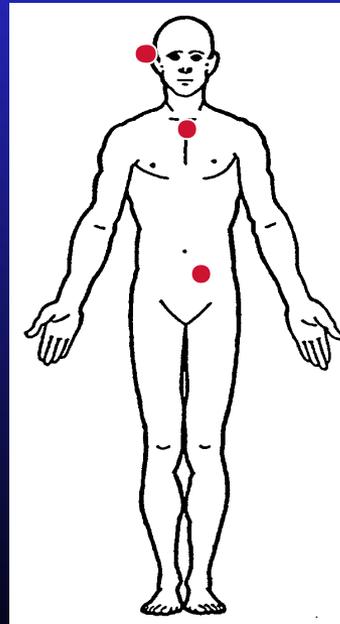
43 cm intrusion







Posterior scalp avulsion

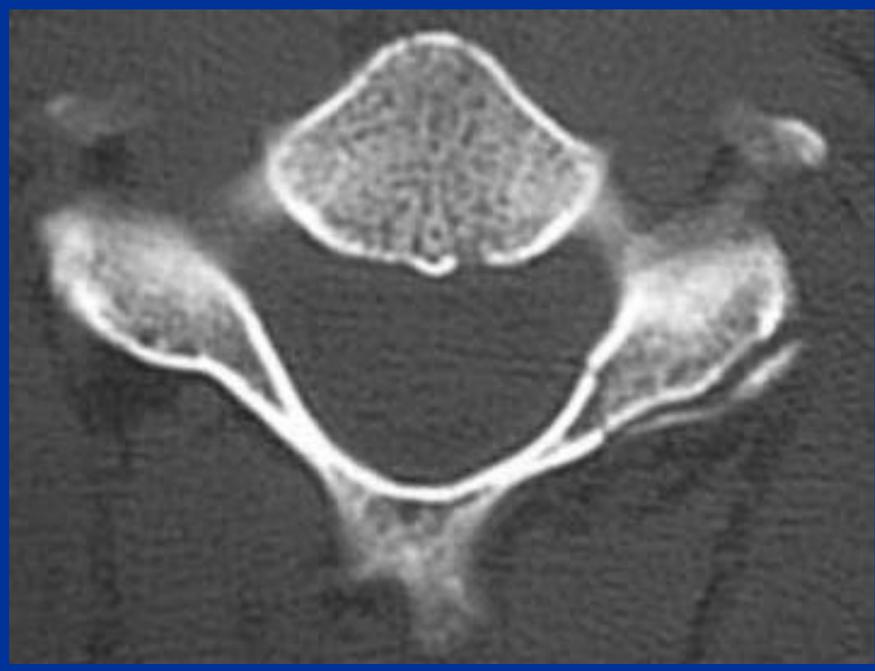


Left comminuted C4-5 facet fx. and C4 lamina fracture

Left abdominal contusion

Right ear laceration and contusion









San Diego Case Rollover Examples

Who has head and neck injuries ?



A



B



C

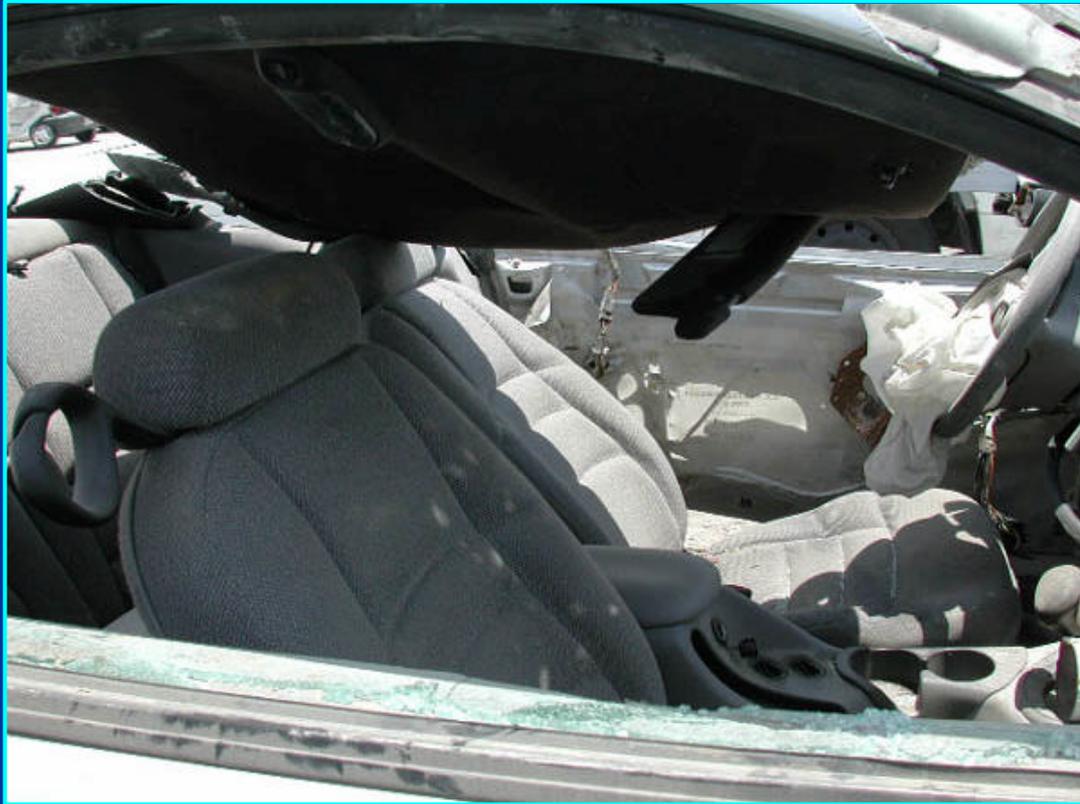


D



E

Patient A

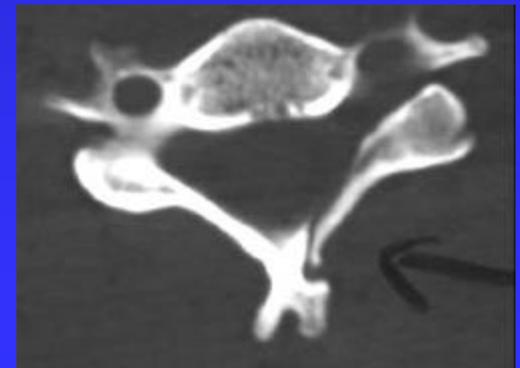
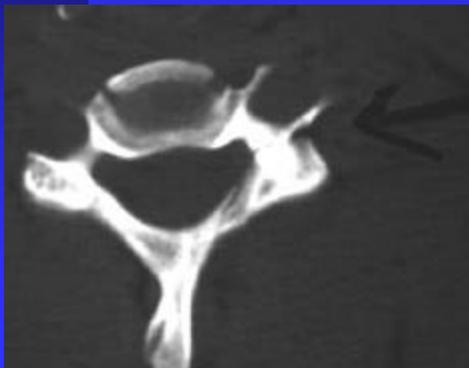


- Driver - 19 y/o male
- Lap & shoulder belt
 - (no pre-10, not integrated)
- Right roll
- 8 ¼-turn, trip-over
- FRP on wheels
- ‘Velocity @ Trip’ 58 kph (36 mph)
- Downward embankment
- 1998 Ford Mustang
- 40 cm M/C @ roof
- 1 greenhouse impact

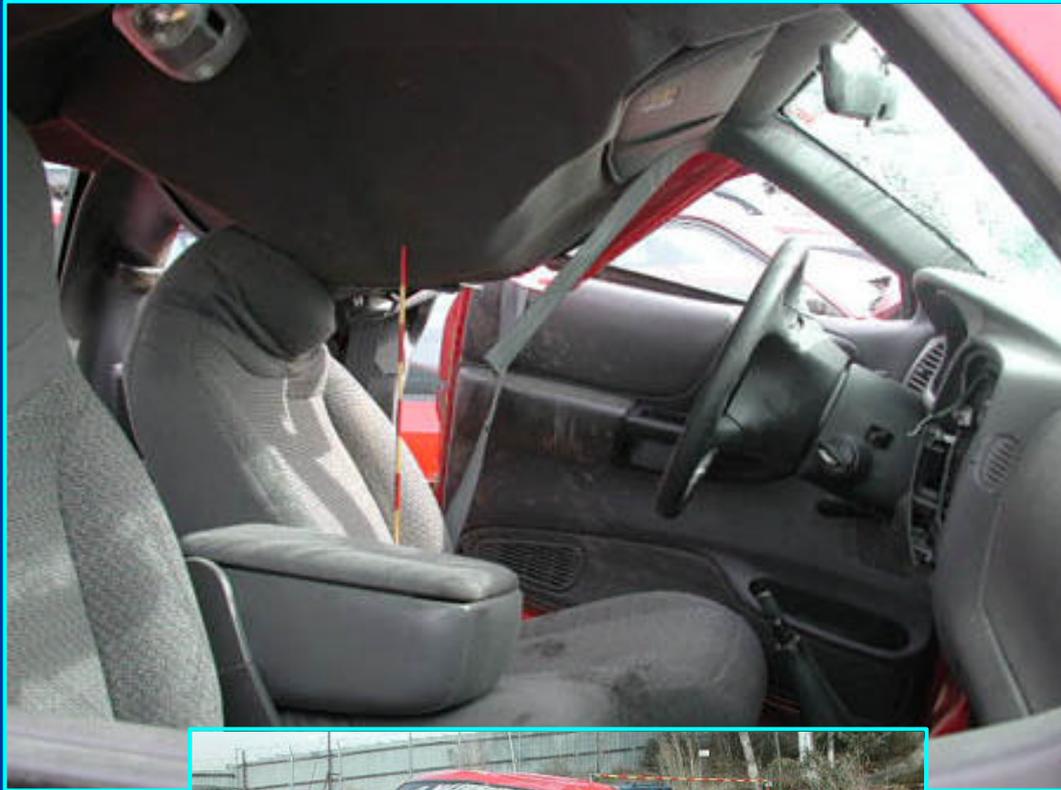
Yes

Injuries

- **Concussion**
- **Left basilar skull fracture (articular condyle)**
- **C1 burst fracture**
- **C5-6 pedicle and lamina fractures**



Patient B



- Driver - 24 y/o male
- Lap & shoulder belt
 - (no pre-10, not integrated)
- Left Roll
- 10 ¼ turn 'trip-over'
- Impact with rock during roll
- FRP on top
- Roadside = small embankment with large rocks
- 1999 Ford Ranger XLT
- 40 cm M/C @ left roof
- 2 greenhouse impacts

No

Injuries

- **Left rib fractures 7th-10th @ costotransverse junction**
- **Splenic laceration, Grade 3**

Patient C

- RF passenger, 25 yo female
- Lap/shoulder belt used
 - (no pretensioner, not integrated)
- Right Roll
- 8 quarter-turn fall-over
- Steep embankment with large rocks
- 1999 Chevrolet S-10 pick-up
- 50 cm max crush
- 2 greenhouse impacts (rock)



No

Injuries

- **Left forehead abrasions**
- **Left proximal humerus fracture**

Patient D

- Driver - 36 y/o female
- Lap & shoulder belt used
 - (no pre-10, not integrated)
- Right Roll
- 10 quarter-turns
- ‘Overturn’ on roadway
- FRP on top
- 1998 Toyota 4Runner
- 35 cm M/C @ left roof
- 2 greenhouse impacts



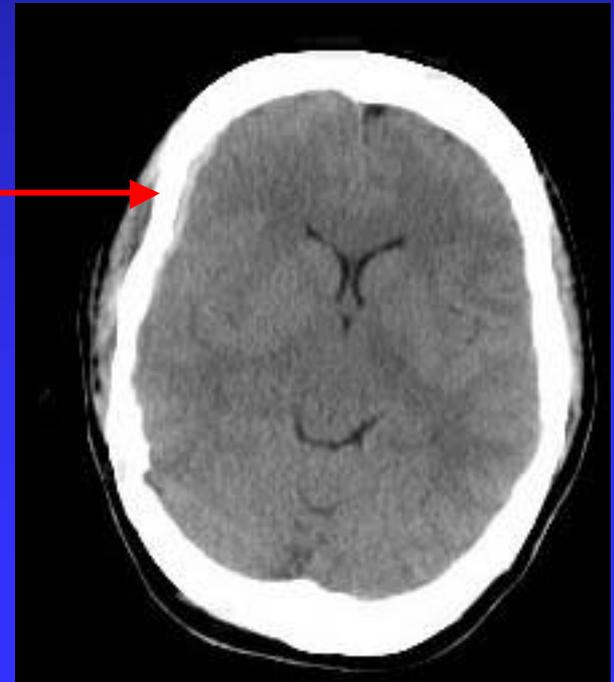
Yes

Injuries

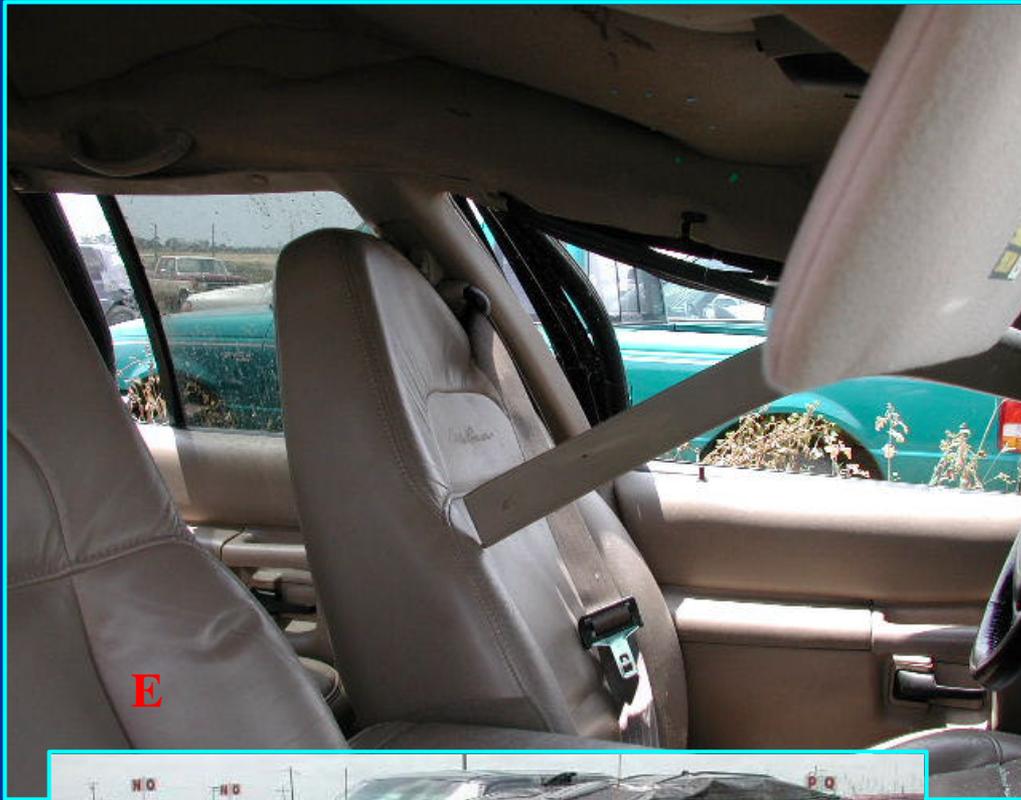
- **Right small frontal SDH**
- **Right frontal cephalohematoma**
- **Right parietal scalp laceration**



Right eye



Patient E

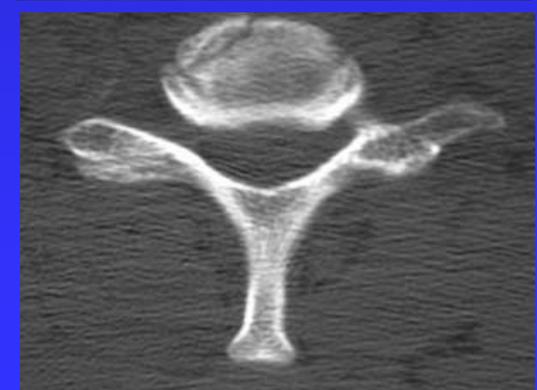
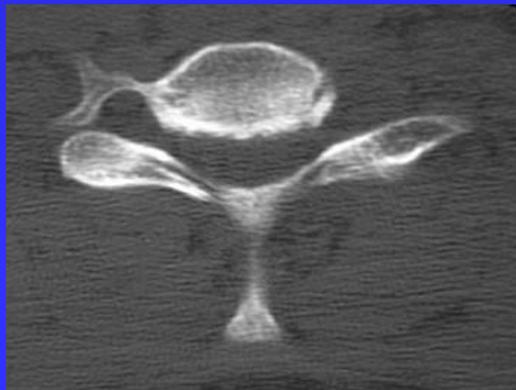
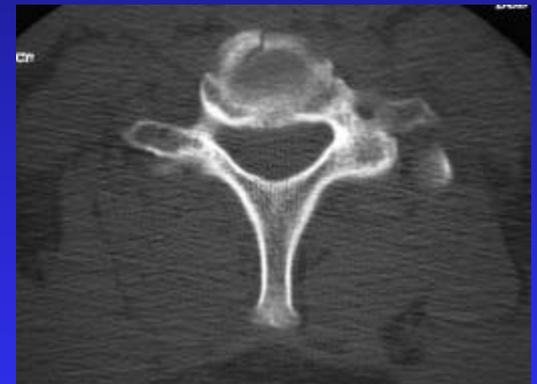
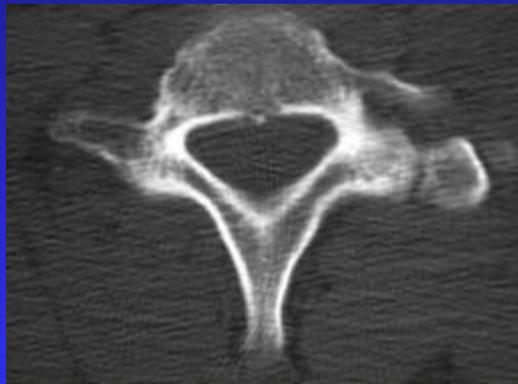


- Driver - 44 y/o female
- Lap & shoulder belt
 - (no pre-10, not integrated)
- Left Roll
- 10 ¼ turn, ‘trip-over’ tripped on roadside median
- FRP on top
- Velocity @ ‘Trip’ 27 kph (17 mph)
- 1999 Ford Explorer
- 35 cm M/C @ ‘A’ pillar/roof rail/roof

Yes

Injuries

- **Concussion**
- **Left ear laceration**
- **C6 vertebral body fracture**



Implications for Triage & Treatment

- Even in the Absence of Roof Crush:
 - Think spinal injury !!
 - Patients often self-extricate

Research Questions

- What is the optimal seat belt design?
 - Pretensioners
 - 5 point harness
- What is the interaction between roof crush and occupant kinematics
- How can we best classify skipping stone and plop rollovers?

Does NASCAR Have The Solution To Crash Safety?



Search



Hot At NHTSA

Crash Tests

Site Map

Recalls

Buying A Safer Car

Service Bulletins Database

Impaired Driving

Popular Information

- Air Bags
- Auto Safety Hotline
- Calendar
- Career Opportunities
- Child Passenger Safety
- Child Seat Inspections
- Complaint Form
- Crash Statistics
- Crash Tests
- Disability Information
- Docket Management System
- Driver Distraction
- E-Payment
- Feedback
- FOIA
- Grants
- Hot@NHTSA
- International Activities
- NCSA
- Press Releases
- Publications Catalog
- Real Videos
- Recalls
- Safety Materials
- School Buses
- Speeches
- Star Ratings
- Table of Contents
- Tires
- What's New



Vehicle & Equipment Information

- Problems & Issues
- Testing Results
- Regulations & Standards
- Research & Development



Traffic Safety / Occupant Issues

- Injury Prevention
- Driver Performance
- Communications & Outreach
- Crash Information



Welcome To NHTSA

- Announcements
- What's NHTSA Doing?
- DOT Auto Safety Hotline
- Regional Offices

NEWS

The honorable Jeffrey W. Runge, M.D. Administrator National Highway Traffic Safety Administration before the Committee on Commerce, Science, and Transportation United States Senate (2/26/2003)

NHTSA Announces Safety Recall of Gorking, Seelcase Child Restraints (02/27/2003)

Restraint Use Rises to Record High Level for Infants and Toddlers (02/10/2003)

NHTSA Publishes List of November Recalls (01/23/2003)

Information regarding NHTSA's national telephone survey on traffic safety issues (01/08/2003)

Child Safety Seat Registration Proves Effective in Notifying Owners of Recalls, NHTSA Evaluation Report Shows (01/06/2003)

NHTSA Warns Of Potential Buckle Problems On Child Seats Equipped With Recessed Buckles (12/30/2002)

Historic Impaired Driving Crackdown Is Launched; NHTSA Releases State-By-State Report (12/18/2002)

U.S. Transportation Secretary Mineta Announces Proposal to Improve Fuel Economy Standards For Model Year 2005-2007 Light Trucks (12/13/2002)

NHTSA Publishes List of October 2002 Recalls (11/27/2002)

[More press releases...](#)

Buckle Up America
Child Passenger Safety Week
 February 9-15, 2003



www.nhtsa.dot.gov